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PONDEROSA PINE TREE CLASSES REDEFINED

Forest Insect Laboratory
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Portland, Oregon

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By
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Senior Entomologist
Forest Insect Investigations

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Introduction.

In studying the relative susceptibility of ponderosa pines to bark-beetle attack, a tree classification (5) was set up, combining four stages of maturity (1, 2, 3, and 4) with four degrees of crown vigor (A, B, C, and D), making 16 tree classes in all. While this classification developed as an expansion of Dunning's classification (3) and was originally designed merely for study purposes, the fact that it embodied fundamental silvicultural principles, the simple arrangement of the classes, and the ease with which it could be learned and applied by field men gained for it an unexpected popularity and usefulness in applied timber management.

Outside the entomological field it was first used by Brandstrom in connection with light selection cuttings on the Hines timber sale near Burns, Oreg., and following this, was adopted by the Forest Service and Indian Service as a basis for timber marking rules in ponderosa pine stands of Oregon and Washington, where the objective was to remove from 40 to 60 percent of the mature and overmature trees of poorest thrift, but having sufficient value to pay their way.

An adaptation of the classification was made by Hornibrook (4) to fit conditions found in the Black Hills of South Dakota and Wyoming. Analyzing the growth rate of the different tree classes, he found a highly significant difference between the means of growth for age classes and vigor classes both in the uncut stands and in the response following release by partial cutting. In other words, he found that the tree classification was a satisfactory criterion of the relative growth capacities of Black Hills ponderosa pine, either in uncut or in selectively cut stands.

In the southwest, another adaptation of the system has been developed by Assistant Forester Walter C. Thomson (6) after a very thorough study of age, crown characteristics, and growth rates of ponderosa pines in that region. Since it is generally recognized that the rate of growth of a tree is directly proportional to the area of leaf surface, Thomson made adjustments in the crown classes so that their relative growth rates would fall in four categories, from Class A, representing the best, to Class D, the poorest. Crown position was subordinated to crown size and vigor.

Using four crown vigor classes (A, B, C, and D) arranged according to growth rates, but finding age classes unnecessary, Taylor (7) developed a similar system of tree classification for lodgepole pine in Colorado and Wyoming.

Thus the system of classifying trees according to four stages of maturity and within each maturity class according to crown size, as an indication of relative growth rate and tree vigor, has wide

application and usefulness in silvicultural and entomological studies and in the practical aspects of timber marking, provided that the tree classes can be defined with sufficient exactness so as to be readily recognized by anyone giving the subject careful study. Unless the classes are precisely defined with scant leeway, for personal judgment, there is a chance for considerable disagreement between the users of any tree classification. Borderline trees will be thrown one way by one man and into the next class by another. Or even one man may reverse himself as to a tree's class, on examining it from two different angles.

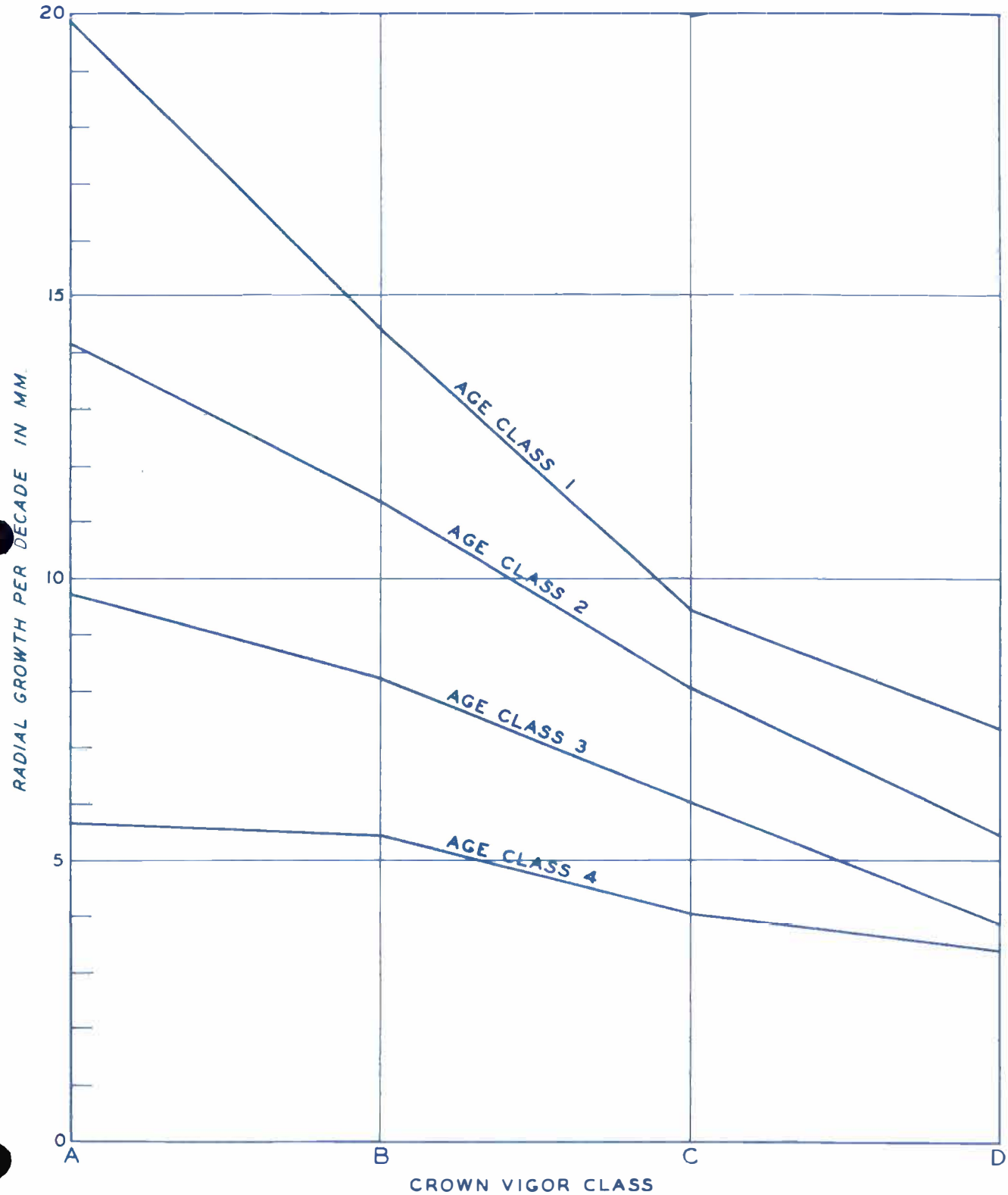
Recently in connection with timber sale contracts in Region 6, where certain tree classes are specified for cutting, there has arisen the need for more precise standards than were included in the original descriptions. While these were sufficient for study purpose, where field crews were all instructed according to one standard interpretation, there was some confusion when many people attempted to apply the written descriptions to field practice without the benefit of verbal instructions. There was the question of what to do when several of the criteria of a certain class were in conflict. For instance, should a tree in a suppressed position, but with long needles and obviously good vigor, be classified as a "D" or put in a better grade? How about a large tree with the dimensions of an "A" crown but with thin, sickly foliage? Should it still be called an "A" crown or rated lower? What about spike-topped trees? While these exceptions to the general rule might be few and far between, they at least were puzzling and brought up the question as to what criteria of a tree class should be given the greatest weight.

FIGURE 1

COMPARATIVE GROWTH OF PONDEROSA PINE TREE CLASSES DURING 30-YEAR PERIOD 1900-1929

EASTERN OREGON

BASIS 3,477 TREES



To give the tree classes greater exactness of definition, and to harmonize these, as far as possible, with the interpretations of Hornibrook and Thomson, additional study has been given to tree classification during the past year and new definitions prepared which should help in ironing out such ambiguity as existed in the original descriptions. Secondly, a "tree class calculator" has been designed, which, like a photographic exposure meter, improves the estimating by considering the more important factors which go to make up a tree class. This calculator also will serve the purpose of standardizing interpretation of tree class in various parts of this region where it applies.

Methods of Study.

In the fall of 1938, fourteen 10-acre sample plots were established in various parts of the ponderosa pine region in eastern Oregon. On these plots, all of the ponderosa pines 10 inches d.b.h. and over, totaling 3700 trees, were tagged, and their characteristics fully recorded. In addition, an increment core was taken from each tree and later in the laboratory these were measured by decades, and for the last two five-year periods. All trees were classified as to tree class by the field crew establishing the plots, and these were later checked by the writer as mentioned below.

For each plot, growth rates were averaged by tree class and the general average growth rate for each tree class determined by sites (figure 1).

These data were then taken into the field and the trees studied as to growth rate and assigned tree class. In cases where growth rate of a particular tree departed markedly from the average of its assigned tree class, the tree was reappraised as to the characters which indicated this departure and how the tree class description might be modified to bring closer together trees of similar growth rates. The effort here was to keep the average of each tree class in the same relationship as in the original description, but to bring the exceptional and borderline trees closer in line with their proper class.

The net result of this appraisal of tree classes in relation to growth rates was to set up more specific standards for each tree class, particularly as to crown vigor classes, which in the past had given the most difficulty. The revised descriptions of age and vigor classes are given below.

Description of Tree Classes.

The two primary factors upon which this tree classification is based are age and crown vigor. Each of these factors is subdivided into four parts, making a total of 16 tree classes. While the same four ages and four crown vigor subdivisions can be recognized in any ponderosa pine stand, or in any other coniferous stand for that matter, the tree characteristics which differentiate the age or vigor group vary considerably in different parts of the pine region and on different sites and hence cannot be described specifically, except for a particular site and for limited portions of the region. Thus, the

following descriptions apply primarily to average Site IV in central and southern Oregon and northeastern California. Hornibrook has given the corresponding descriptions for the Black Hills ponderosa pine, and Thomson has described the characteristics of similar age and vigor groups in the southwest. Other modifications will be needed to fit conditions in other localities, but the general principles are the same anywhere.

Age classes. Trees are first divided into four age groups—young, immature, mature, and overmature. The purpose here is to recognize relative maturity or "physiological age" rather than any definite age limits as shown by annual rings. Differences in site, moisture, elevation, and other environmental factors influence the age at which trees reach maturity in different parts of the ponderosa pine region. Judging from height curves, the ages at which trees reach the same relative maturity class on different sites are shown below:

Table 1

Theoretical Age Limits for Maturity Classes

Maturity Class	Site Index				
	40	60	80	100	120
1. Young	0 - 50	0 - 70	0 - 75	0 - 80	0 - 90
2. Immature	50 -100	70 - 130	75 - 150	80 - 160	90 - 180
3. Mature	100 -200	130 - 250	150 - 300	160 - 350	180 - 400
4. Overmature	200+	250+	300+	350+	400+

Analysis of the actual ages of 1630 trees classified according to this system on the 10-acre plots in eastern Oregon gave the following age limits:

Actual Age Limits for Maturity Classes

Maturity Class	Site Quality III-	IV	V
1. Young	0 - 100	0 - 90	0 - 80
2. Immature	100 - 200	90 - 210	80 - 170
3. Mature	200 - 300	210 - 280	170 - 280
4. Overmature	300+	280+	280+

The external characters most valuable as indicators of maturity are the color and character of the bark, the total height of the tree, shape of the top, character of branches and branching, and diameter. These characters for Site IV in the ponderosa pine stands of central and southern Oregon and northeastern California are given below and in tabular form in table 2.

Age Class 1.--Young trees, commonly referred to as "bull pines" or "black jacks"; age usually less than 75 years. (Site IV). Thrifty trees making rapid height and diameter growth.

D.b.h. Rarely over 20 inches.

Height. In lower crown canopy; usually less than 60 percent of total mature height.

Bark. Dark, grayish-brown to black, rough, and deeply furrowed, without plates but with narrow ridges between the fissures (sometimes coloring at extreme base.)

Branches. Upturned and in whorls for upper three-fourths of crown; small for diameter of bole.

Top. Usually pointed, with distinct nodes.

Age Class 2.—Immature trees, age approximately 75 to 150 years; still making rapid height and diameter growth in thrifty trees.

D.b.h. Rarely over 30 inches.

Height. Usually less than 90 percent of total height at maturity. Trees still under the general crown canopy.

Bark. Dark reddish-brown, with narrow, smooth plates between the fissures on lower half of bole; dark rough bark on upper half.

Branches. Mostly upturned and in whorls for upper half of crown; horizontal near middle, horizontal or drooping below; small to medium size for diameter of bole.

Tops. Usually pointed, but with nodes indistinct, sometimes rounded.

Age Class 3.—Mature trees; age approximately 150 to 300 years. Height growth practically complete; diameter growth slow.

D.b.h. Rarely over 40 inches.

Height. Practically that of the general crown canopy (except suppressed or top-killed trees).

Bark. Light reddish brown with moderately large plates between the fissures on lower 3/4 of bole, dark bark showing in upper quarter.

Branches. Upturned near top; middle crown horizontal; lower branches drooping; moderately large for size of bole.

Tops. Usually pyramidal or rounded, occasionally pointed; whorls indistinct except at extreme top.

Age Class 4.—Overmature trees; age more than 300 years, making no further height growth; diameter growth very slow.

D.b.h.	Wide latitude in diameters, but usually large in dominant trees.
Height.	Full height of general crown canopy (except suppressed spike-topped or broken trees).
Bark.	Light yellow and uniform for entire bole, except in extreme top; the plates usually very wide, long, and smooth; fissures often rather shallow.
Branches.	Large, heavy limbs, often gnarled or crooked; mostly drooping except in extreme top.
Tops.	Usually flat, occasionally rounded or irregular.

The distinction between age classes 1 and 2 is based largely on color and roughness of bark, and character of branching. While both are sometimes called "bull pines" or "black jacks" only class 1 trees have the rough, black bark for practically the entire length of bole, and upturned branches in distinct whorls, so characteristic of young, juvenile growth. Class 2 trees have this dark, rough bark in the upper half of the bole, but the bark on the lower half is turning red and developing narrow plates on the ridges.

The distinction between age classes 2 and 3 is mainly a matter of height, character of the bark, and branching in the upper part of the tree. Class 2 trees are understory trees, somewhat less than 90 percent of full height at maturity, while Class 3 trees have practically reached the height of the general crown canopy and only show dark bark and upturned branches in the upper quarter of the crown.

The distinction between age classes 3 and 4 is more difficult to recognize, since there is no sharp line of demarcation between a mature and overmature tree. Light yellow or colored bark for practically the entire bole, absence of dark bark on the bole except at the extreme top, large, heavy limbs, mostly horizontal or drooping, are the principal distinguishing features of overmaturity.

In the field, age classes of dominant and codominant trees are readily recognized. Suppressed and intermediate trees in the older age classes often cause more difficulty, since their diameters are small and they frequently simulate the characters of younger trees. Since ponderosa pine usually grows in even-aged groups, the age class of the surrounding trees will usually give a clue to the age of suppressed individuals in the group.

Crown Vigor Classes. It is a well recognized silvicultural principle that the growth rate of trees for a given site and age class is directly proportional to the size of crown or area of leaf surface (2). Therefore, in this classification, each age class is subdivided into four subgroups, based on size of crown and abundance of foliage. These classes, grouping together trees of similar growth capacities, indicate four degrees of relative crown vigor and are designated A, B, C, and D from best to poorest.

In considering tree vigor, there are two points which should be kept in mind—one is the inherent growth capacity of the tree, which depending upon crown size and position, changes but slowly over a period of years, unless suddenly changed by breakage or fire; and secondly,

is the current health or vigor of the tree which may fluctuate from year to year, depending upon current available moisture and food supply, or the debilitating effects of fire, insects, disease, or pathological conditions. The length of needles, their color and the number of years' compliment retained, and the presence or absence of dying portions of a tree give the best indication of current health conditions. Since the foliage only represents four or five years of growth at most, it can only serve to indicate the current situation. On the other hand, the size of living crown, the position of the tree and diameter attained indicate its growth capacity over a longer period of time. The present tree classification is primarily concerned with the inherent vigor and growth capacity of the crown rather than the current health of the tree. The tree health situation can be indicated by adding + or - to the tree class designation if the tree is currently improving or declining in vigor.

In studying the growth rate of trees in relation to crown characteristics, the following factors, in order of their importance, were found to be the best outward indicators of crown vigor and inherent growth capacity:

(1) Size of crown—length, width, and circumference.
(2) Density of crown.
(3) Form of top—pointed, round, flat, or spiked.
(4) Position—isolated, dominant, codominant, intermediate, or suppressed.

Apparently in uneven-aged stands, such as open-grown ponderosa pine, position as to dominance or light is of minor importance as compared with size and density of crown. Size of crown usually reflects the tree's position and amount of root competition.

In defining the four crown vigor classes, it is impossible to describe all the variations in crown shape which may be encountered. Crown size and density are the principal criteria and these can best be compared to typical trees of crown class A, which might be considered as the ideal outline. In the following descriptions, it should be understood that other shapes may still belong to that crown vigor class, provided the total volume of crown comes within the established limits.

The crown vigor classes are defined as follows:

A. Full vigor.

Crown: Full vigorous crowns with a length of 55 percent or more of the total height, and of average width or wider; with density average or better.

Foliage: Needles of average length or longer, usually dense and thrifty.

Position: Usually isolated or dominant (rarely codominant).

D.b.h.: Large for age.

B. Good to fair vigor.

Crown: Good to moderately vigorous crowns with length from 30 to 55 percent of total height, if of average width and density; or a longer crown if narrow or somewhat thin; but neither sparse nor ragged.

Foliage: Needles of average length, usually dense and thrifty.

Position: Usually codominant but sometimes isolated or dominant; rarely intermediate.

D.b.h.: Average or above for age.

C. Fair to poor vigor.

Crown: Fair to poor crowns, with length from 10 to 30 percent of total height if of average width and density, or long, sparse, and narrow; often flat on one or more sides.

Foliage: Needles often short and thinly distributed, but of normal length and density when confined to top 1/3 of tree.

Position: Usually intermediate, sometimes codominant or suppressed, but rarely isolated.

D.b.h: Usually below average for age, sometimes large in decadent trees.

D. Very poor vigor.

Crown: Very short, less than 10 percent of the total height, sometimes merely a tuft at top of tree, or somewhat longer when sparse and ragged; usually very narrow or limbs all on one side.

Foliage: Needles often short, and foliage sparse or scattered or only tufts at end of twigs; but of normal length and density if reduced in quantity.

Position: Usually suppressed or intermediate, but may occupy other positions if greatly reduced in vigor.

D.b.h: Decidedly subnormal for age, but very old decadent trees may be of large diameter.

These tree classes are illustrated in the accompanying chart which has been prepared from field sketches. Tabulations of the characters defining the maturity and vigor classes are given in tables 2 and 3.

A Tree Class Calculator.

To eliminate as far as possible the personal equation and to standardise interpretation of the various tree classes, a "tree class calculator" has been devised, which puts the essential factors of tree classification on a rule of thumb basis. A separate rule for maturity and crown class determination is shown in the accompanying chart. The weight given to factors used in the construction of these rules was determined by a statistical analysis of the 3477 trees described on the 14 10-acre plots. The methods of curvilinear multiple correlation described by Bruce and Reineke (8) were followed in making this analysis.

Crown Class Rule. Crown class as indicated by this slide rule is simply determined by the multiplication of relative length of crown, width of crown, and density of crown, as compared with the ideal outline of an "A" crown tree. The formulas might be written as follows:

(See page 15)

Crown Class = L x W x D x S in which

L = Percent of crown length as compared with total height of tree. (In case of spike-top trees, the original total height of tree has to be assumed.)

W = Percent of width of crown as compared with the normal width of full-crowned "A" tree of similar height. (In trees of unsymmetrical crown, width is best taken as the radius of the widest side.)

D = Percent of density or fullness of crown as compared with normal fullness of an "A" tree. (This is best estimated by visualizing the crown pushed up the tree to fill the upper cone to normal density and then estimating what percent of total crown length would be filled.)

S = This is a correction factor (70 percent) for spike-topped or suppressed trees.

Operation of rule:

(1) Pull slide until "W" is over "Length of crown %" determined.

(2) Slip runner to "Width of crown %" determined.

(3) Pull slide until "D" is under cross hair of runner if tree has normal top, or use "S" if the tree is suppressed or spike topped.

(4) Read crown class on upper scale above the "density of crown %" determined as applicable.

Maturity Class Rule. This rule was first computed in the form of an alinement chart from a multiple curvilinear correlation analysis of the factors involved, and then converted to slide rule form. It was found that of the several factors tested, the percent of black bark and the diameter were the most important in determining relative maturity. Slight corrections were found to be needed for the various crown classes and for sites other than Site IV.

"Black bark %" is defined as the proportion of rough black bark characteristic of rapidly growing bark on a Class 1 tree, or that on the leader of older trees. In Class 1 trees this bark covers 100 percent of the bole. In older trees only a small percent of the top shows this growing condition. In older trees, where the limits of the black bark are not easily discernible, the point where the limbs are horizontal (drooping below and upturned above) can be used instead, for a satisfactory approximation.

Operation of the rule:

If on Site IV:

(1) Pull slide until crown class letter (previously determined) is over "black bark %".

(2) Read maturity class above appropriate D.b.h.

If Site III or Site V are involved, after step (1):

(2) Slip runner to "Av"

(3) Push slide until appropriate site is under hair line of runner.

(4) Read maturity class above appropriate D.b.h.

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Table 2—Maturity Classes.

Character	Class 1	Class 2	Class 3	Class 4
Maturity	Young.	Immature.	Mature.	Overmature.
Age	Usually less than 75 years	Approximately 75-150 years	Approximately 150-300 years	More than 300 years.
D.b.h.	Rarely over 20 inches.	Rarely over 30 inches.	Rarely over 40 inches.	Usually large diameters in dominant trees.
Height	In lower canopy, height usually less than 60% of total height at maturity.	Height usually less than 90% of total height of mature canopy.	Height practically that of general crown canopy (except suppressed or intermediate trees).	Full height of general canopy (except suppressed or intermediate trees).
Growth and Taper	Thrifty trees making rapid height and diameter growth; rapid taper.	Considerable height growth still in progress; good diameter growth in thrifty trees. Taper considerable.	Height growth practically complete; diameter growth slow. Moderate taper.	Making no height growth. Diameter growth very slow. Least taper.
Bark Color	Dark grayish-brown to black (except at extreme base).	Dark reddish-brown on lower 1/2 of bole, dark bark in upper 1/2.	Light reddish-brown on lower 3/4 bole; dark bark showing in upper 1/4 of bole.	Light yellow, uniform color throughout bole (except at extreme top).
Bark Plates	No plates. Rough bark, deeply furrowed with narrow ridges between fissures.	Narrow smooth plates between fissures.	Moderately large plates between fissures.	Plates usually very wide, long, and smooth; fissures often rather shallow.
Branches	Branches upturned in upper 3/4 of crown; small for diameter of bole	Mostly upturned in upper 1/2 of crown; lower half horizontal or drooping; small to medium for diameter of bole.	Upturned near top; middle crown horizontal; lower ones drooping; moderate for size of bole.	Large, heavy limbs, often gnarled or crooked; mostly drooping, except in extreme top.
Nodes and Whorls	Whorls and nodes distinct in upper crown.	Whorls distinct in upper half of crown.	Whorls indistinct except at extreme top of crown.	Whorls indistinct and incomplete.
Top	Top usually pointed.	Tops usually pointed; sometimes rounded.	Top usually pyramidal or rounded; occasionally pointed.	Usually flat; occasionally rounded, or irregular.

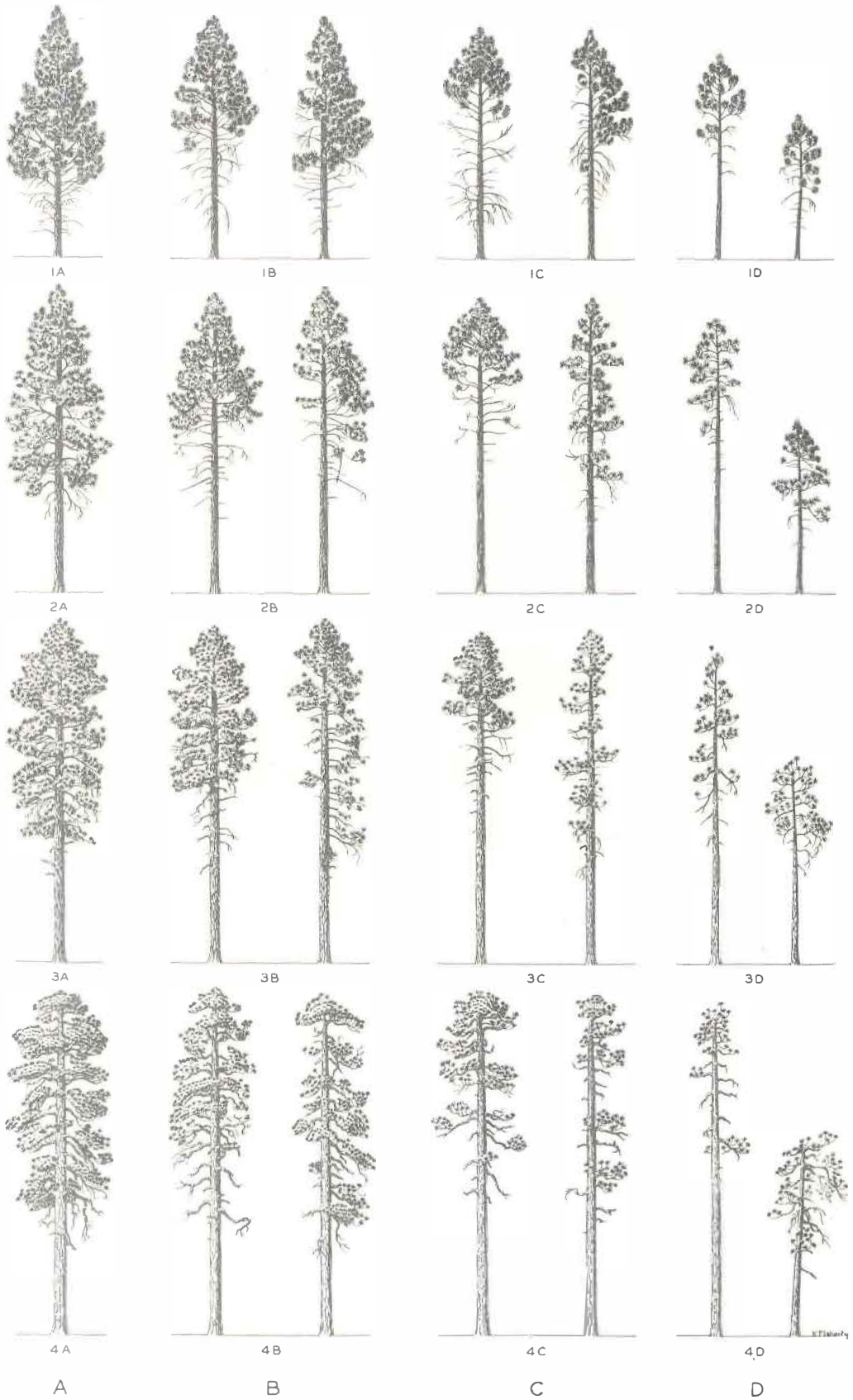
Table 3.--Crown Vigor Classes.

Character	A	B	C	D
Crown Vigor	Full, vigorous.	Good to fair.	Fair to poor.	Very poor.
Crown Length	Long--55% or more of total height; or less, only of more than average width.	Average length--less than 55% of total height (approx. 30% to 55% if full and wide) or a longer crown if narrer or somewhat thin.	Short--(from 10% to 30% of height if crown of normal density), or long, sparse, and narrow.	Very short (less than 10% of total height), sometimes merely a tuft at top of tree, or somewhat longer when sparse and ragged.
Crown Width	Usually average width or wider (or narrower if very long and dense).	Usually average width or narrower. May be flat on one side.	Usually narrow or flat on one or more sides.	Usually very narrow and sparse, or limbs all on one side.
Crown Density	Usually full and dense or medium density if longer than 55%.	Usually of full to medium density, not sparse or ragged.	Often sparse and ragged except at very top.	Sparse and ragged.
Foliage	Needles of average length or longer, usually dense and thrifty.	Needles of average length; usually dense and thrifty.	Needles often short and thinly distributed, but of normal length and density when confined to top 1/3 of tree.	Needles often short, and foliage sparse or scattered or only partially developed; but of normal length if reduced in quantity.
Position	Usually isolated or dominant; rarely codominant.	Usually codominant; sometimes isolated or dominant; rarely intermediate.	Usually intermediate; sometimes codominant or suppressed, but rarely isolated.	Usually suppressed or intermediate, but may occupy other positions if greatly reduced in vigor.
Diameters	Large for age.	Average or above for age.	Usually below average for age; sometimes larger in decadent trees.	Decidedly subnormal for age, but very old, decadent trees may be of large diameter.

Note: The descriptions apply to the usual types of trees found in each class; where exceptions occur, the size of living crown and amount of foliage are the primary considerations in determining the vigor class.

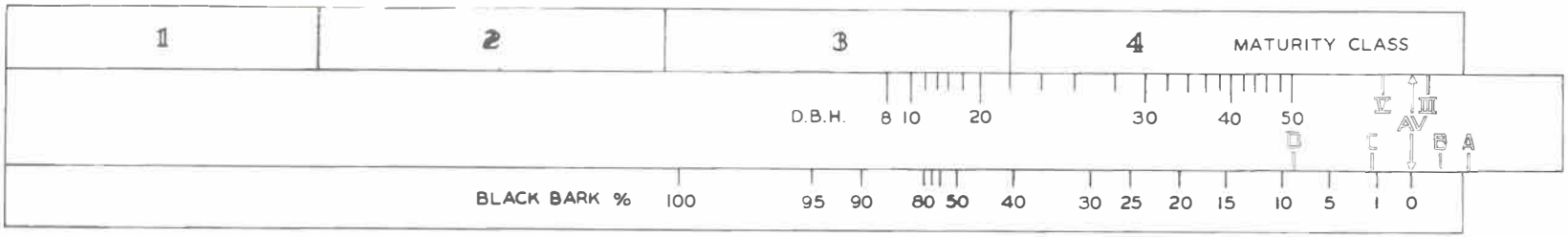
A PONDEROSA PINE TREE CLASSIFICATION

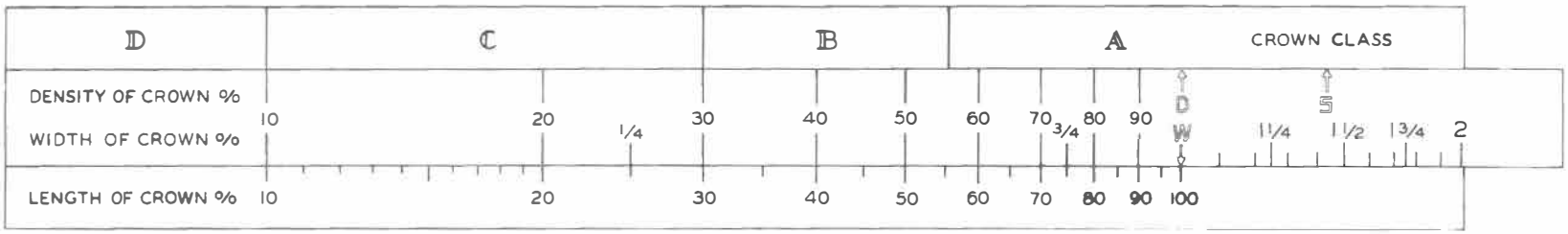
BASED ON AGE AND VIGOR

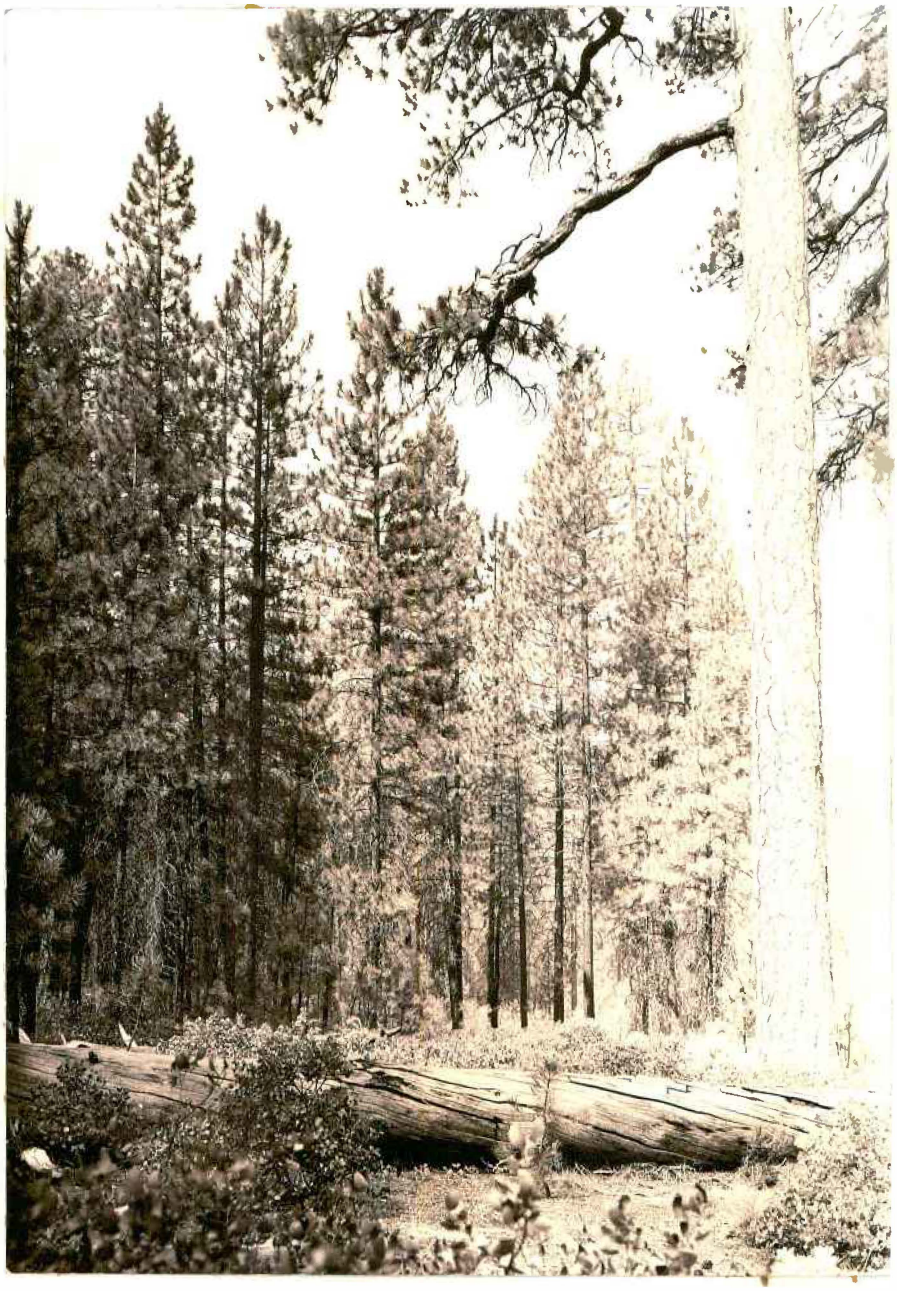


TREE CLASS CALCULATOR

(These rules can be cut out and mounted on any slide-rule, but are especially designed to fit an 8-inch wooden rule #8-B, manufactured by the Lawrence Engineering Service, Peru, Ind., usually carried by stores selling school supplies.)

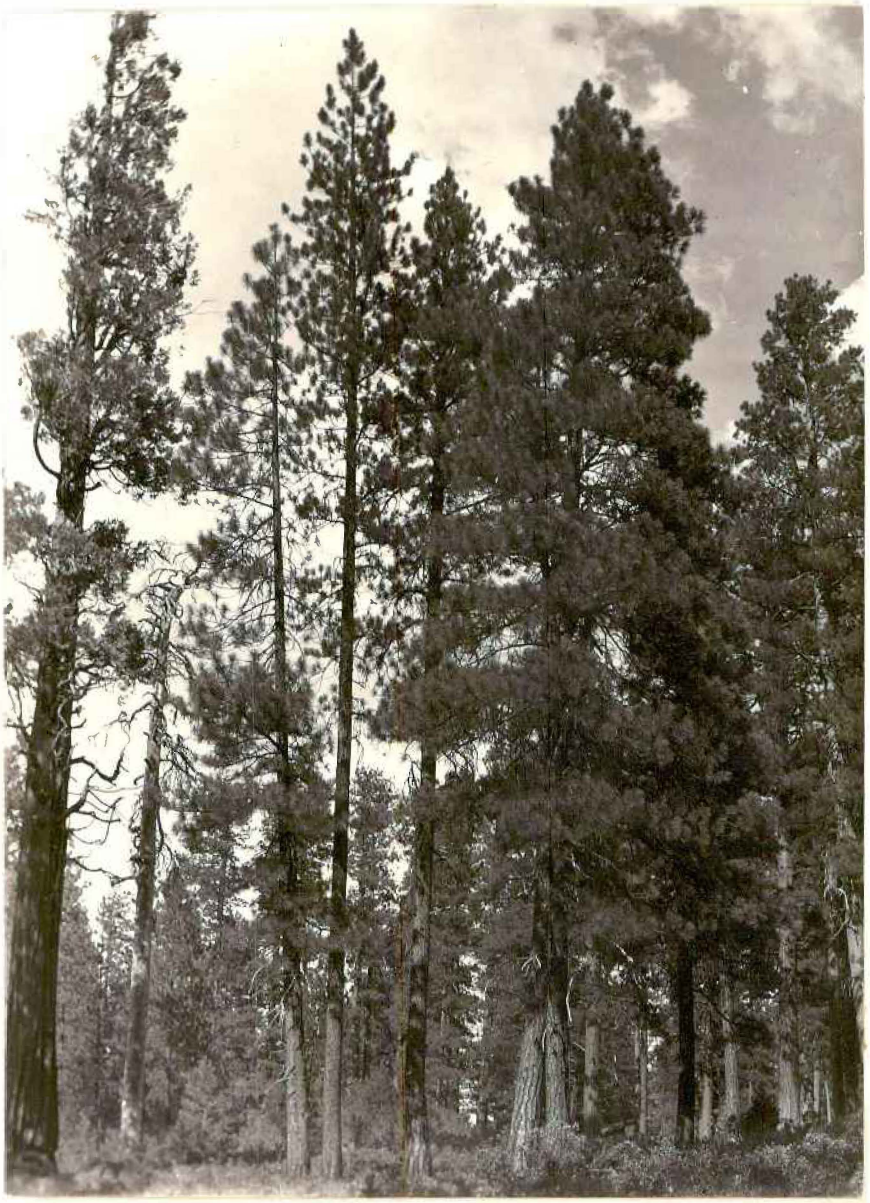




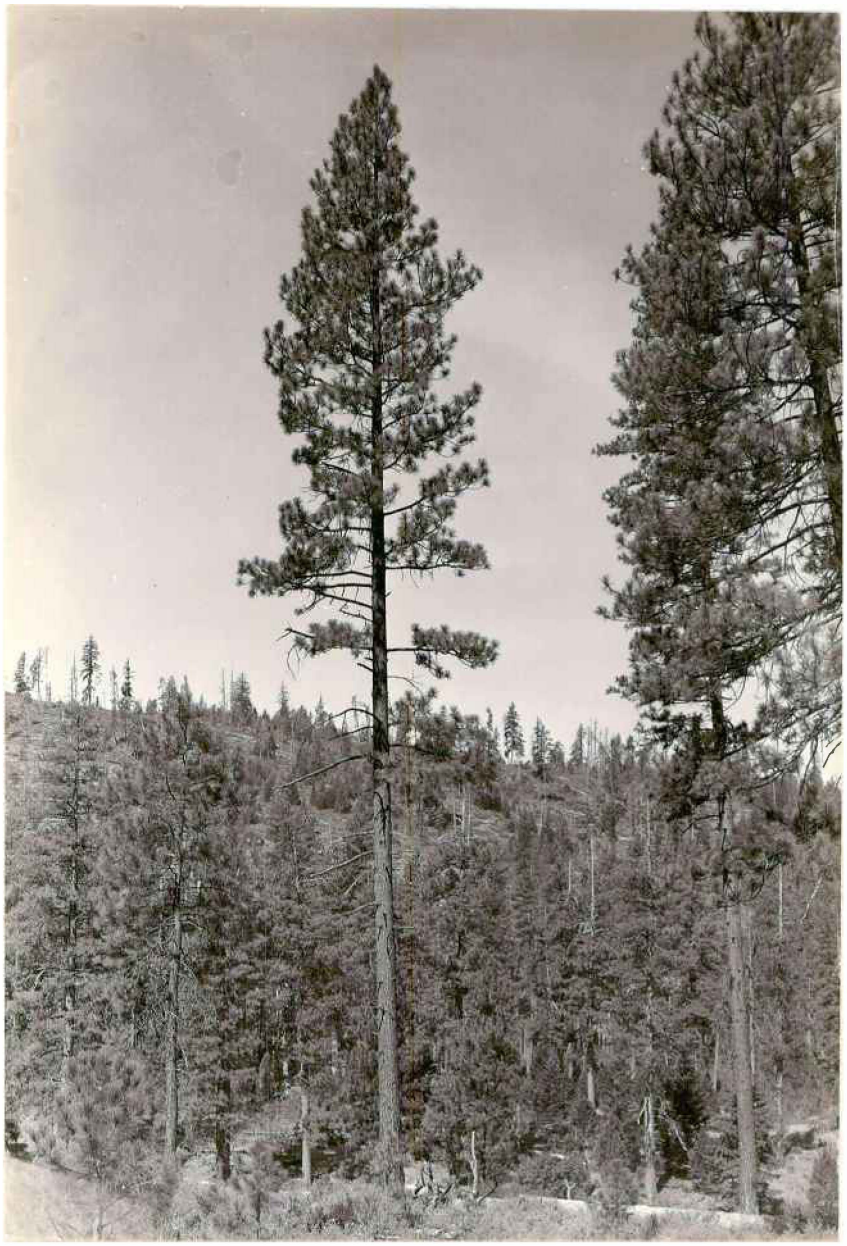


A group of Class 1 Trees.

A typical Class 1A tree.

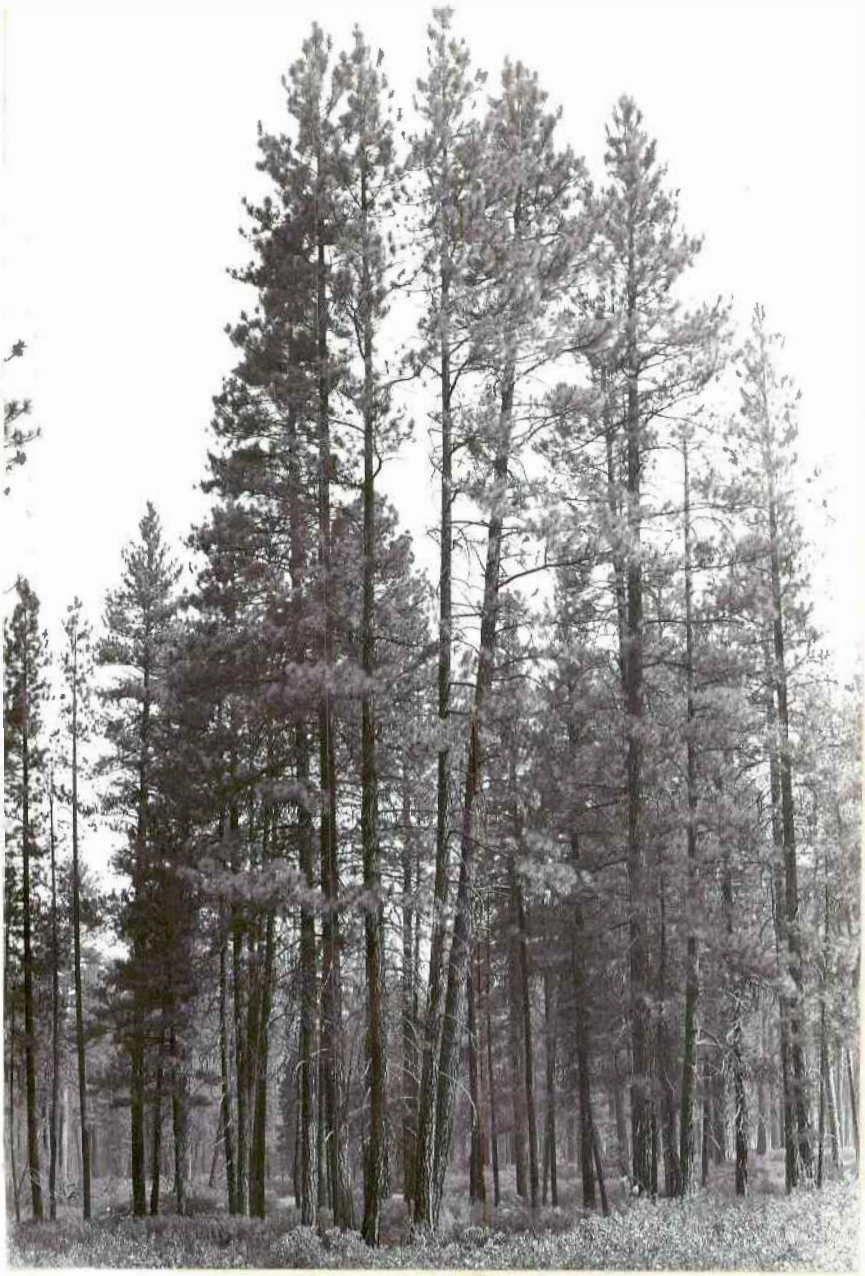


A group of Class 2 trees.
Crown Class A on right, B in center, C for two trees on left.

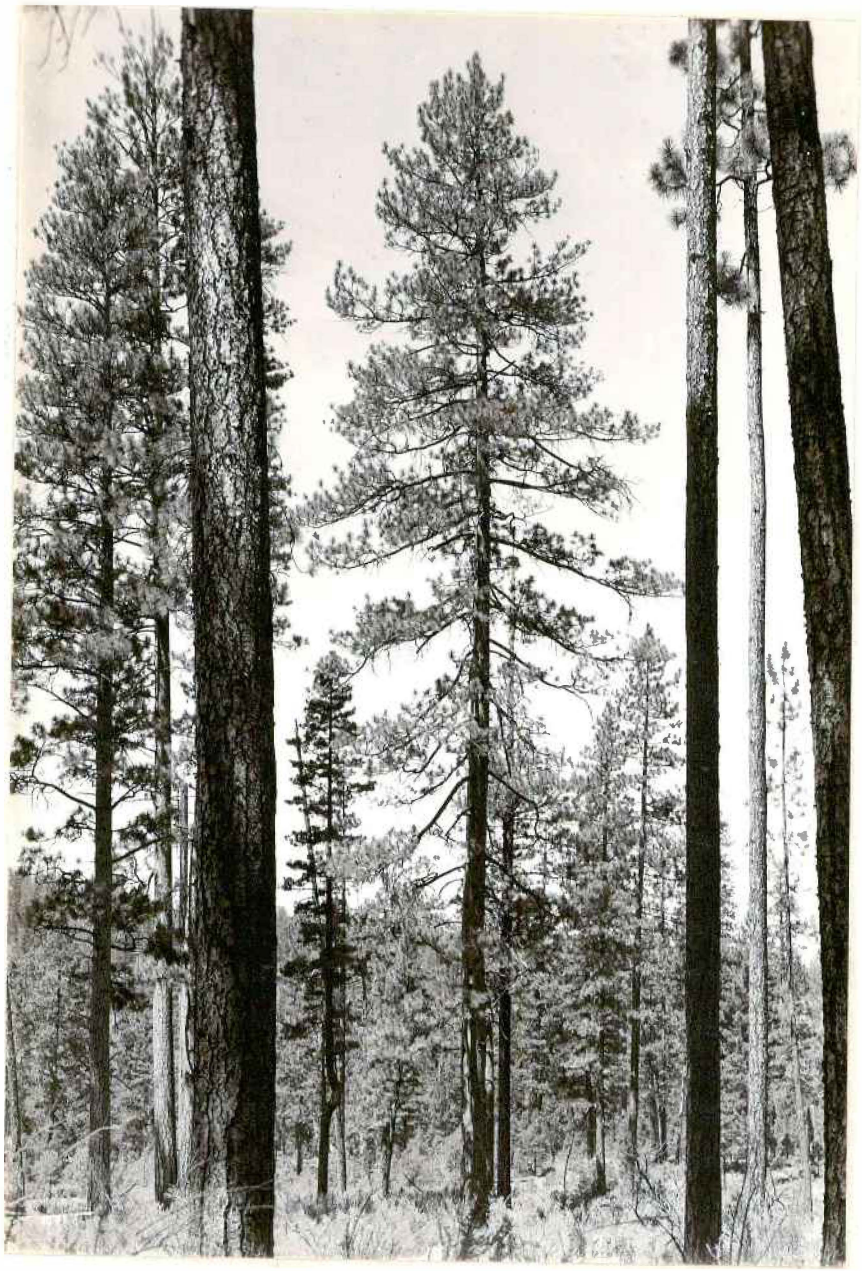


A typical Class 2S tree.

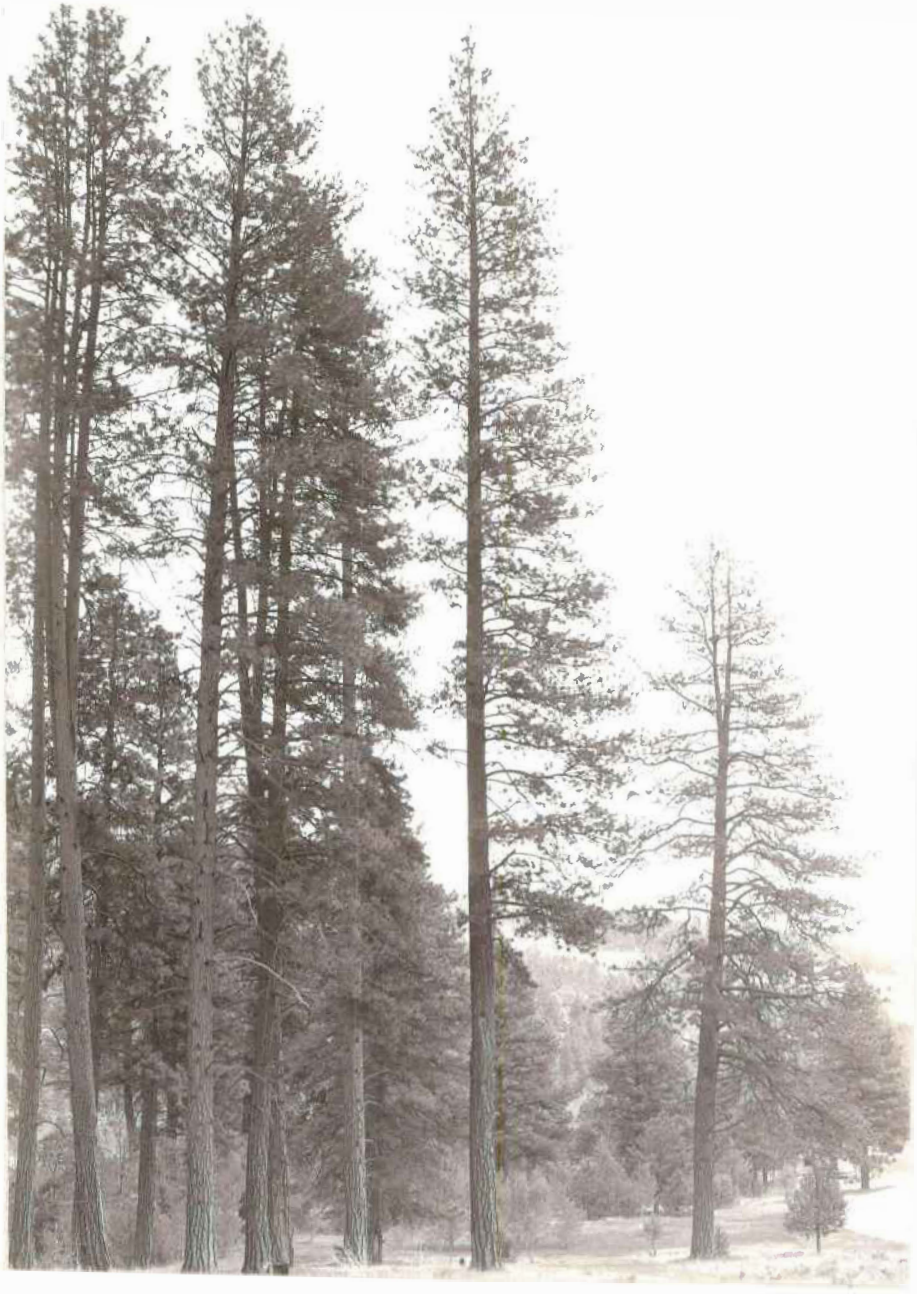
Class 2B on right.
Class 2D on left.



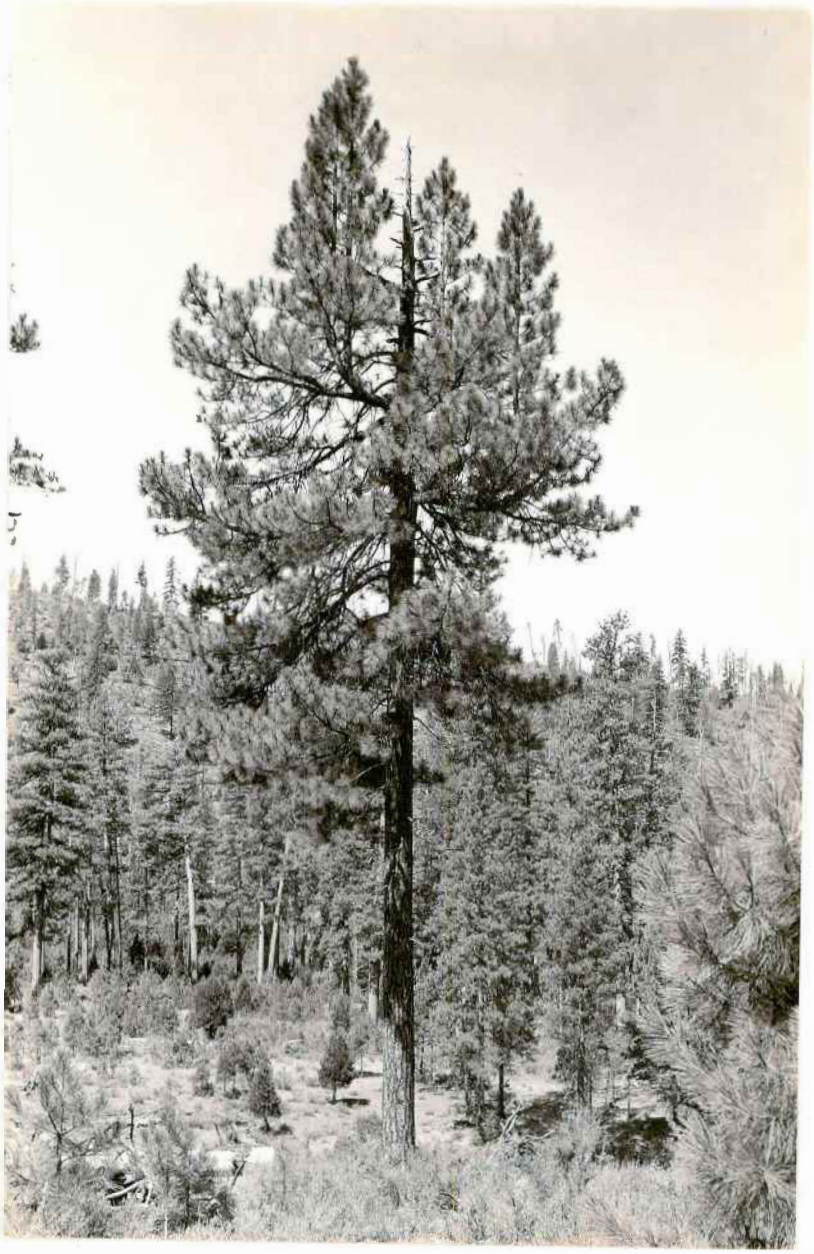
A group of Class 2 trees composed of Crown Classes B and C.



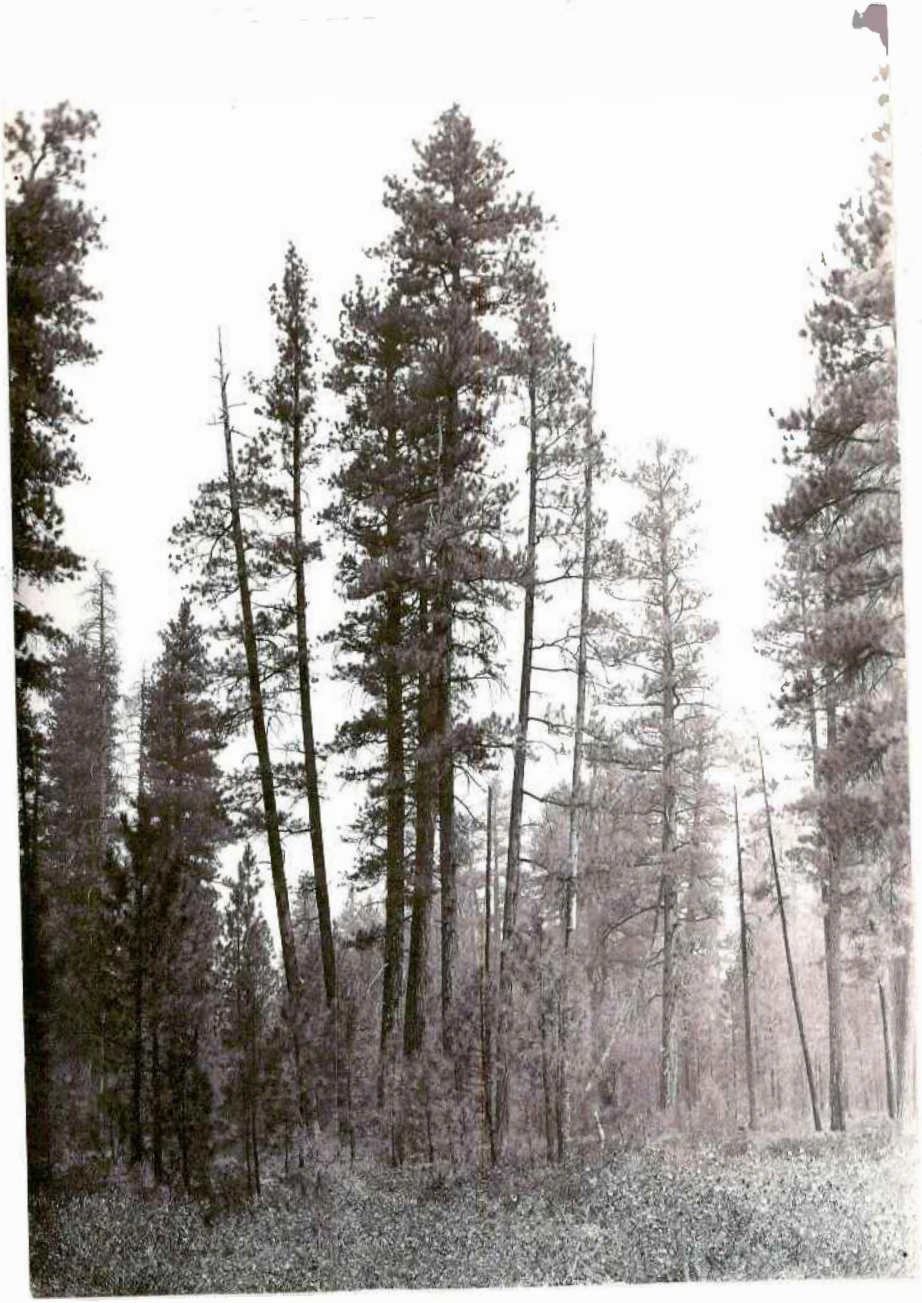
A Class 3A tree.



A group of Class 3 trees of B and C crowns.

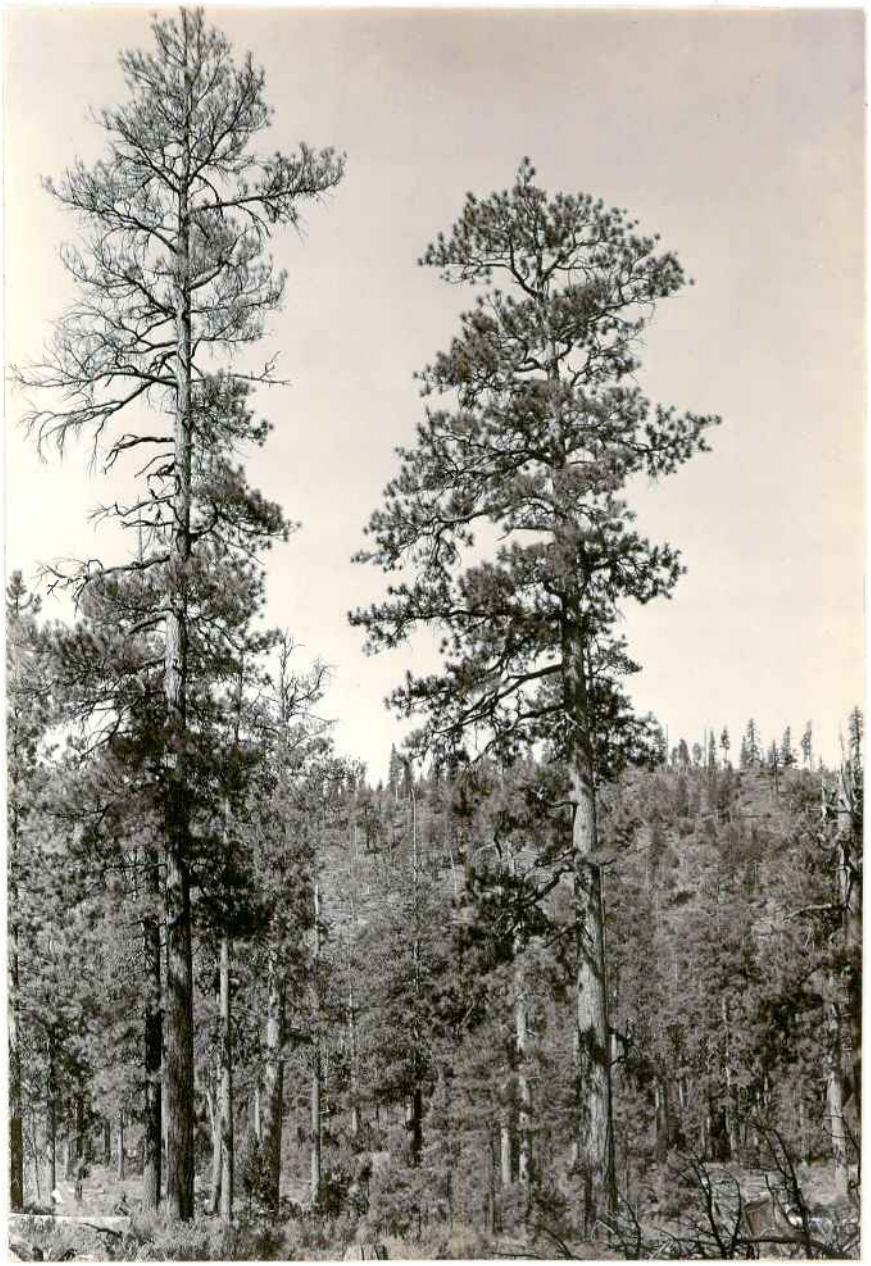


A Class 3C tree. This would have been a Class 3B tree except for the spike top, which throws it into the lower class.

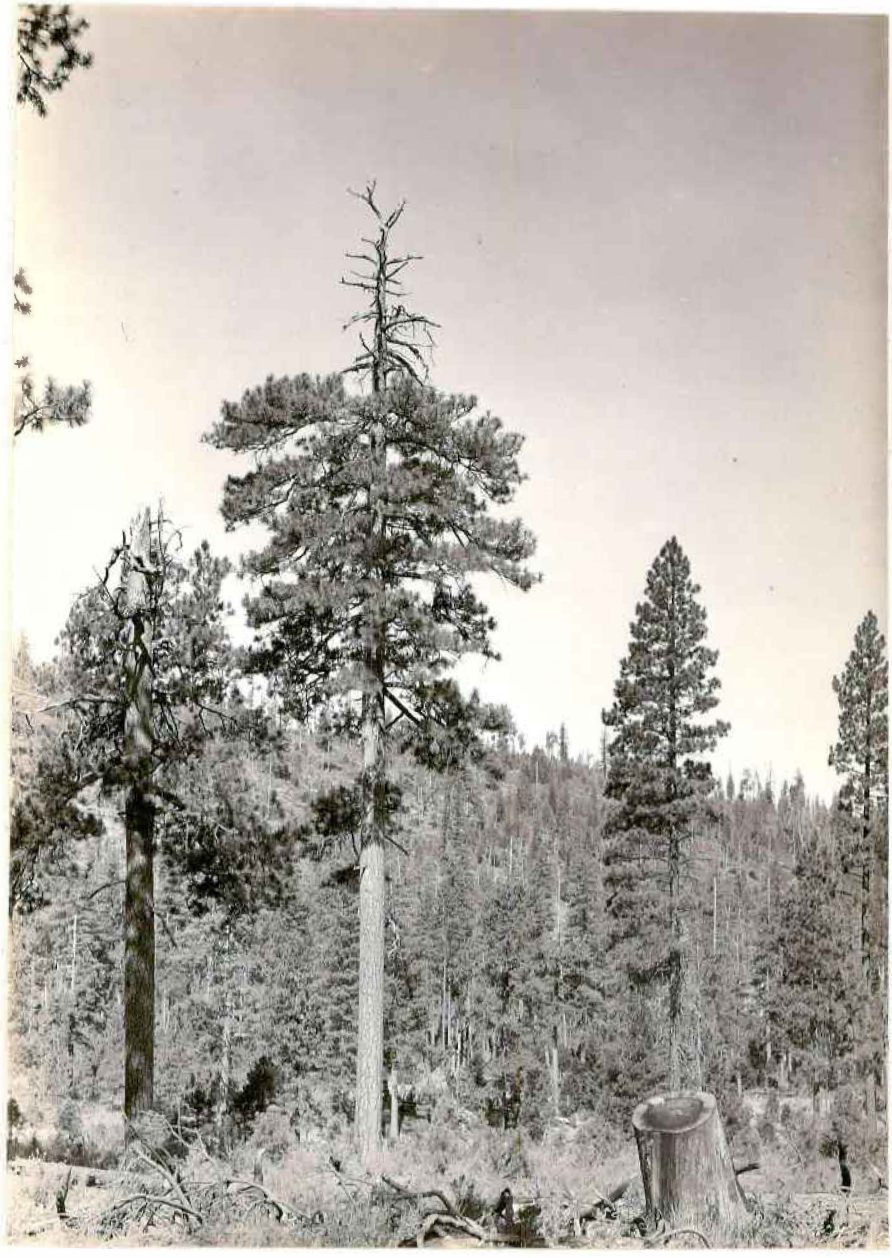


A group of Class 3C and 3D trees.

A Class 4A tree.



Two types of Class A3 trees.



A tree declassed to 43 because of spike top.

A typical suppressed type of 4D tree.

A large Class 4D tree.

COMMENTS ON KEEN'S REDEFINITION OF HIS PINE TREE CLASSES

Page 3 - 2nd paragraph

The realization that these discrepancies were intimately tied up to infestation and loss prompted the development of the risk ratings. We have not found these discrepancies to be few or far between.

Page 7

Descriptions of age classes. What percent of classes 1 and 2 are thrifty. I believe most of them are but are all of them thrifty.

Page 11.

This also refers chiefly to the conditions we have tried to recognize in the risk ratings.

Page 12.

Use of vigor and density as terms should be as he qualifies them previously. Otherwise they should be called inherently vigorous or branch spacing dense, etc. to take care of his plus and minus use of our risk rating characters for current health. He has previously pointed out that changes in growth rate and presumably in current health seem to be more closely tied up with loss and infestation.

Page 19.

Needle length and density. These appear in the description but are they correlated with crown length and width, density, position of tree and diameter. I think the criticism that they are not correlated remains and it would be better to leave them out of his descriptions and attempt to use our risk ratings as his plus or minus or recognize the risk ratings and give credit for the work.

Plate 12.

As an example plate 12 shows two 4B trees, one of which is a risk 4 and the other a risk 2.

It would seem to me that the criticisms he levelled against the first draft of the manuscript on Black's Mountain results applies to this paper if it is intended as a manuscript.

K. A. Salman

June 17, 1940